The other case is that of the Report on the Mollusks of the deep-sea dredging expeditions sent out by France, 1880–83, in the Travailleur and Talisman. The first volume of this report by Arnould Locard,* on the Testaceous Mollusks, includes the Cephalopods, Pteropods and Gastropods as far as Litiopidæ. It is illustrated by excellent lithographic plates and is chiefly descriptive. A superficial examination gives the impression that the abyssal fauna of the eastern Atlantic does not materially differ in character from that of the American border of the same ocean, but that, so far as it does differ, it confirms the impression that the abyssal mollusk fauna of any coast is strongly tinctured with the faunal characteristics of the shallow waters of that coast; so that, while there are some ubiquitous or almost ubiquitous species and many ubiquitous genera, the deep-sea fauna will eventually be divisible into almost as many provinces as there are recognizable among the different faunas of the sea margin.

We congratulate the author on the appearance of this weighty instalment of his work, and desire to assure him that we also know what it is to publish through a government printing office.

WM. H. DALL.

ON THE LAW OF ANCESTRAL HEREDITY.†

THE Darwinian theory has for its main factor the perpetuation of favorable variations by natural selection under the law of heredity. Hence any complete quantitative treatment of evolution must deal: (1) with the nature and distribution of variation; (2) with the nature and influence of selection, and this not only upon the selected but upon all the correlated characters or organs; and (3) with the law of heredity. Earlier published and other written but unpublished papers of the present writer cover to some extent the ground of (1) and (2). Although the mathematical theory of variation and selection is yet very far from completion, the general lines on which it will proceed seem, to the present writer at any rate, fairly clear. With the law of heredity, however, the case has hitherto been different. Much has been written on the subject, much has been attributed to inheritance, but the quantitative measurements and facts have formed such a small and slender proportion of the whole that it has been extremely difficult to base a rounded mathematical theory on what is really known. It was with a view to the collection of further facts that the writer started his collection of Family Measurements, which would now have reached completion were it not that certain collateral relationships are still numerically somewhat deficient. Such facts are so all-important for real progress in our knowledge of heredity that the writer is convinced that there ought to be a comprehensive and systematic collection of them by some public body; the labor is beyond the powers of any unaided individual.

When the writer of the present paper wrote his memoir on Heredity, in 1895,* the only available material was contained in Mr. Francis Galton's *Natural Inheritance*, and in the data and measurements in Mr. Galton's hands, which he at once placed, with his usual generosity, at the writer's disposal. The very suggestive theory of heredity developed in the *Natural Inheritance* has two main features: (*a*) a theory of regression, which states the average proportion of any character which will be inherited under any degree of relationship. This theory was very simple; if the aver-

* 4°, pp. iv + 516, Pl. I.–XXII.; Paris, Masson et Cie., 1897.

† 'Mathematical Contributions to the Theory of Evolution.' Abstract of a paper read before the Royal Society by Professor Karl Pearson, F.R.S., University College, London, January 27, 1898.

* *Phil. Trans.*, Vol. 187, A, p. 253.

age of the sons of any parent had w of the parent's deviation from the average parent, then the average grandson would have w^2 of the deviation, and so on. Collateral heredity was also determined, and for two brothers was found equal to $2w$. Mr. Galton's value of w was $\frac{1}{3}$.

(*b*) A law of ancestral heredity. According to this law the two parents contribute $\frac{1}{4}$, the four grandparents $\frac{1}{8}$, the eight great-grandparents $\frac{1}{16}$, and so on, of the total heritage of the average offspring. Mr. Galton, in 1889, considered this law to rest on a somewhat slender basis.*

In the *Philosophical Transactions* memoir of 1895 the writer started from the general theory of multiple correlation, and supposed the coefficient of heredity to be a quantity which had to be determined by observation for each pair of relatives and for each character. Mr. Galton's own data, when treated by the fuller mathematical theory developed in that memoir, seemed to demonstrate that fraternal could not possibly be twice filial inheritance. But if heredity be looked upon as a quantity to be determined by observation for each organ and each grade of kinship, *e. g.*, if there be no numerical relationship between direct and collateral heredity, then Mr. Galton's law of ancestral heredity must fall to the ground. Accordingly the writer, in 1895, discarded (*b*) and endeavored to develop (*a*) on the general basis of multiple correlation.

The recent publication of Mr. Galton's remarkable paper on ancestral heredity in Bassett hounds has, however, led the writer to reconsider (*b*). If the law be true, then for every organ and for every grade of kinship the amount of heredity is numerically determinable. The solution of the problem of heredity is thrown back upon the solution of an infinite series of linear equations. Their solution gives results which seem to

* *Natural Inheritance*, p. 136.

the writer in good agreement with all we at present know about the influence of heredity in various degrees of kinship. For example, fraternal is no longer *twice* filial regression, but has a value (0.3881) well in accordance with the writer's 1895 calculations on Mr. Galton's data. In short, if we discard Mr. Galton's relations between the regressions for various grades of kinship, and start solely from his law of ancestral heredity,* the whole theory of heredity becomes simple, luminous, and well in accordance with such quantitative measurements as have so far been made. That it confutes one or two purely hypothetical and semi-metaphysical theories is no disadvantage.

It is possible, and the writer believes desirable, to somewhat generalize the Law of Ancestral Heredity. Modifying Mr. Galton's definition of midparent, a conception is formed of the mid-sth parent, a sort of mean of the ancestry in the sth generation, and the contribution of this mid-sth parent to the offspring is assumed to have a constant ratio to that of the mid-$(s+1)$th parent, whatever be the value of s. With this simple law the whole of heredity is found to depend upon a single constant γ, termed the *coefficient of heredity.* γ may vary from organ to organ and from race to race. It may itself be subject to selection, if heredity be not looked upon as *a priori* given and antecedent to any evolution by natural selection. In Mr. Galton's statement of the law, $\gamma = 1$. This may really be the case, but it is not necessary to the theory, and it is not required by any facts as yet observed.

Given this simple law of ancestral heredity, there flow from it the following results :

* It may be *popularly* stated thus, each group of ancestry of the same grade contributes to the heritage of the average offspring double the quantity of the group of the grade above it.

(i) The values of all the correlation and regression coefficients between any pair of relations, *i. e.*, heredity between any grade of individual kinship. The chief of these are actually calculated in the paper.

(ii) The value of the stability that results from any long or short process of selective breeding, and the variability of the breed so established. A coefficient of stability is introduced in the paper and discussed at some length. The consideration of the more rapid influence of in- and inbreeding is postponed.

(iii) The law of cross heredity, *i. e.*, the degree of relationship between two *different* organs in kindred. It is shown that the coefficient of cross heredity for any pair of organs in any grade of kindred is equal to the product of the coefficient of direct heredity in that grade into the coefficient of organic correlation.

(iv) That simple panmixia without active reversal of natural selection does not lead to degeneration.

It may be of interest to add that since the law of ancestral heredity allows for the variability of each individual ancestor from the ancestral type, giving that variability its share in the heritage of the offspring, it is inconsistent with Weismann's theory of the germplasma. It does not, of course, answer one way or the other the question as to the inheritance of acquired characters.

To sum up, then, it seems to the present writer that Galton's law of ancestral heredity leads to, what has not hitherto existed, a rounded and comprehensive theory of heredity. It describes with surprising closeness all facts so far quantitatively determined, and opens up a wide range of conclusions which await testing by fresh data. Should those data be in agreement with its predictions, then the law of ancestral heredity will in the future play as large a part in the theory of evolution as the law of gravitation has played in planetary theory. It is the quantitative basis on which Darwinism, the evolution of species by natural selection *combined with heredity*, will then be placed; and at one stroke it will clear away a veritable jungle of semi-metaphysical speculations and hypotheses, and this for the simple reason that it is based upon quantitative observations and not on verbal subtleties. It will be difficult, perhaps, to make people realize that there is a science of heredity, simple and consistent, in existence; yet even at the present time it is the number of observers and experimenters, rather than the science, which needs to be strengthened.

THE ROYAL SOCIETY'S ANTARCTIC CONFERENCE.

THE Royal Society held an important meeting on February 24th for the purpose of discussing Antarctic exploration, which is at present engaging the attention of the British government. We take from the London *Times* the following account of the discussion:

Dr. John Murray, of the Challenger Expedition, said that, from a scientific point of view, the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic region would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other in regions of the earth's surface about which we knew very little or were wholly ignorant. It was one of the great objects of science to collect observations of the kind indicated, and it might be safely said that without them we could never arrive at a right understanding of the phenomena by which we were surrounded, even in the habitable parts of the globe. Dr. Murray pointed out a fundamental topographical difference between the Arctic and Antarctic. In the northern